Deep Surveys with SIRTF's Infrared Array Camera

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The Infrared Array Camera (IRAC) on NASA's Space Infrared Telescope Facility (SIRTF) will provide imaging at 3.6, 4.6, 5.8 and 8 μm. The four bands are imaged simultaneously in two adjacent 5 arcminute fields with 1.2 arcsecond pixels. The expected point source sensitivities in the four bands are 3, 4, 17, and 24 μJy (5 σ in 200 seconds) for objects well away from the ecliptic. SIRTF Guaranteed Time Observers have specified field surveys to be carried out with IRAC with integration times per position ranging from 90 to over 10,000 seconds. I describe the plans for these surveys and their application to the study of galaxy formation and evolution.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

IRAC GTO ExtraGalactic Surveys

IRAC will achieve extraordinary sensitivity by the standards of groundbased observations at similar wavelengths, but the deepest GTO surveys are all part of the extragalactic program. There are 6 such surveys. Figure 1 shows the area and depth covered by the various surveys, in comparison to previous work.

The IRAC program to measure the cosmic IR background will observe 6 individual fields deeply (about 60 x 200 sec). Flanking fields will receive about 1/2 this exposure. The fields are:

EES-Lynx	8:48:45.52	+44:54:17.0
Lockman-Hole-CXO	10:52:43.0	+57:28:47.5
HDF-North	12:36:47.89	+62:12:30.4

Groth strip (X-ray)	14:17:17	52:24:00
Hawaii-SSA22	22:17:34.83	+0:15:08.9
LBG-DSF2237b	22:39:21.72	+11:55:10.5

These fields will be revisited briefly (9 x 200 sec) at a different solar elongation to allow the zodiacal dust component to be fit and removed. Deep observations of these fields (about 1000 sec per position) with the Multiband Imaging Photometer for SIRTF (MIPS) will also be done.

The objective of this program is to directly measure the cosmic infrared background at 3.6μm, and to set stringent upper limits on it at 4.5, 5.8 and 8μm by subtracting the contributions of objects detected by IRAC from the values measured by COBE/DIRBE at lower angular resolution.

The deep IRAC survey will do 52 dithers each 200sec long over a strip 10' wide and 2 degrees long, aligned with the Groth strip but extending it to the NE. Figure 2 illustrates the placement of these fields on the sky. MIPS will cover this same region (which is also being covered by the DEEP/DEIMOS survey) with 12 slow scans at 24, 70 and 160 μm, each scan generating about 100 sec of exposure time per position. Parts of this region (those overlapping the medium survey below) will be covered with 24 slow scans with MIPS. A few MIPS fields will receive additional exposures in staring (photometry) mode, bringing the total exposure time to several hours at 24μm. Further details on the MIPS GTO surveys will be provided in Marcia Rieke's presentation.

The objective of the IRAC deep survey is to measure the luminosity function in the rest frame near infrared to a redshift of 3. Photometric redshifts will be determined from IRAC photometry as described in Simpson and Eisenhardt (2000). Figure 3 illustrates

how the sensitivity of the IRAC deep survey compares to the flux expected from distant galaxies. Thousands of high redshift galaxies are expected to be found in this survey

The LBG/SCUBA program will cover several Lyman Break fields to a depth of about 1 hour/filter in IRAC, and about 1000 sec in MIPS. Beyond those already mentioned, these are, Q2233, Q1422, and B20902. There are also three SCUBA fields covered to this level - A370, A1835, and Cl0024+16. The objective of this program is measure spectral energy distributions (SED's) over the SIRTF wavelength range for Lyman Break Galaxies, which are selected to have high UV star formation rates, and of SCUBA sources detected at mm wavelengths (and believed to have high dust enshrouded star formation rates). In a few cases measurements of the redshifted 7.7μm PAH feature will also be made using SIRTF's Infrared Spectrograph (IRS).

The Evolution of the Star Formation Rate program observes fields where extensive redshift surveys have been undertaken. These are generally covered to a shallower level with IRAC - 5 x 100 sec. In addition to the fields mentioned elsewhere, SSA17, SSA13, CFRS1 2 and 3, EES Cetus and SA57, CNOC 0223 0920 and 1447, CFGRS-J0053 will all be observed. Altogether the intent is to cover 0.75 sq deg, including the cosmic IR background and LBG SCUBA fields. They also get 5 slow scans with MIPS. The objective of this program is to build up SED's for a large number of galaxies with redshifts of up to one and measure changes over this redshift range, for which a factor of 10 rise in star formation rate has been estimated.

The IRAC medium survey covers 5 deep x-ray fields regions 25' wide by 1 degree high, to a depth of 5 x 100 sec. These same regions are covered by MIPS with 12 slow scans. The regions are:

Chandra South deep	3:32:28	-27:48:30
Lockman Hole	10:52:43	57:28:48
HDF-North	12:36:47.89	62:12:30.4
Groth strip (X-ray)	14:17:17	52:24:00
XMM deep	13:34:37	37:54:44

Several of these are illustrated in Figure 4. The objective of the medium survey is to search for far-infrared luminous objects and measure their SED's, using the x-ray data to determine if active galactic nuclei are present

Finally, the IRAC shallow survey (Figure 5) will cover 10 square degrees in the NOAO Bootes deep wide field area, to a depth of 3 x 30 sec. MIPS observations of the same field will also be obtained, to a depth of 10 medium scans, each about 45 sec per position. The primary objectives of this IRAC program are to search for clusters of galaxies and for brown dwarfs. The K-band data being obtained by NOAO for this region will be

combined with IRAC 3.6 and 4.5 μm data to measure photometric redshifts out to z=2 (Figure 6 note that 3.6μm and 4.5 μm are labelled L and M in this figure.) Of order one hundred galaxy clussters with redshifts greater than 1, and a few brown dwarfs, are expected to be found in the IRAC shallow survey.

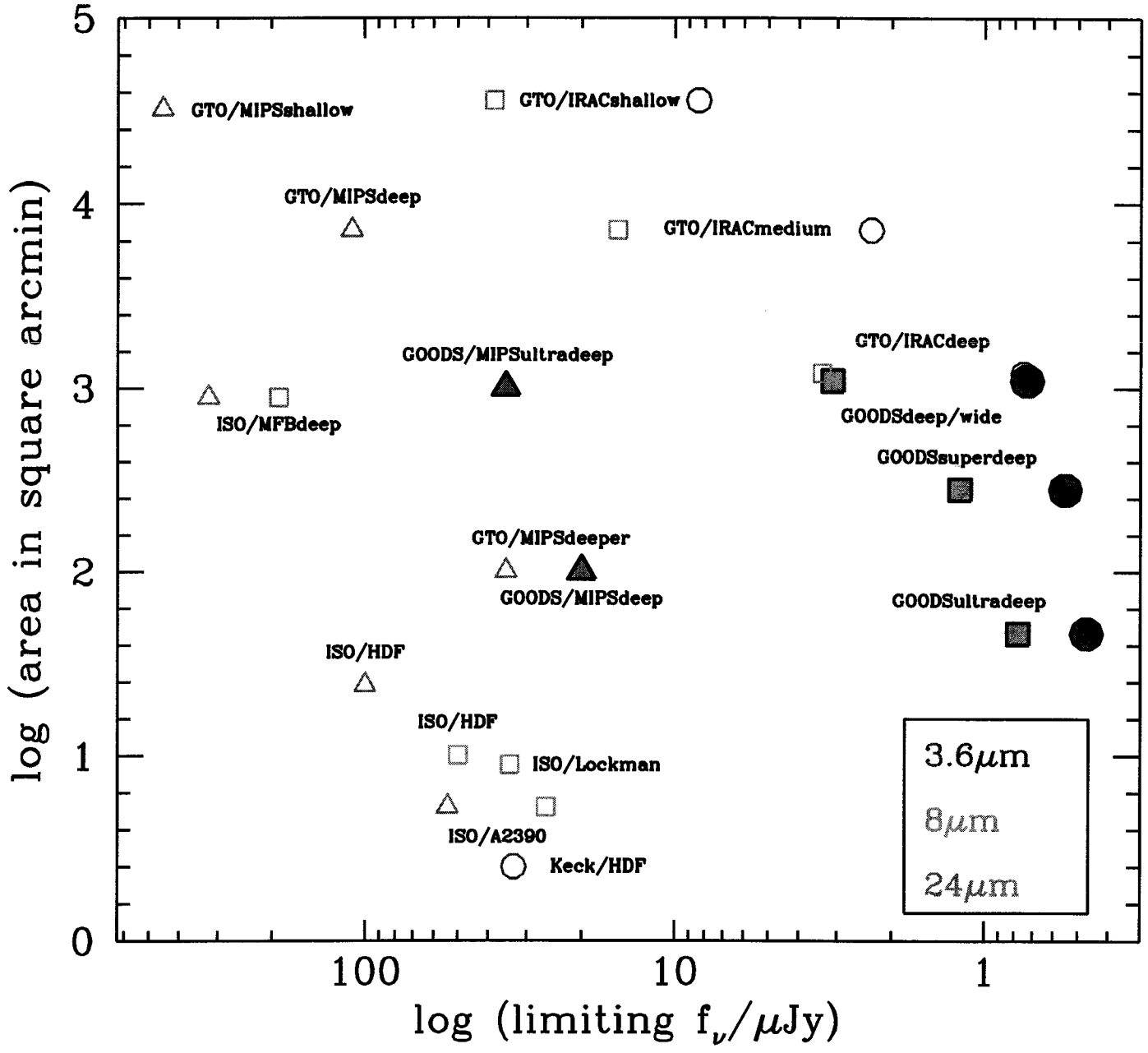

GTO/MIPSshallow
GTO/IRACshallow
GTO/MIPSdeep
GTO/IRACmedium
GOODS/MIPSultradeep
GTO/IRACdeep
ISO/MFBdeep
GOODSdeep/wide
GOODSsuperdeep
GTO/MIPSdeeper
GOODS/MIPSdeep
GOODSultradeep
ISO/HDF
ISO/HDF
ISO/Lockman
ISO/A2390
Keck/HDF
3.6μm
8μm
24μm
log (area in square arcmin)
log (limiting f_ν/μJy)
0
1
2
3
4
5
100
10
1

Fig. 1

IRAC Deep Survey of the Groth Strip

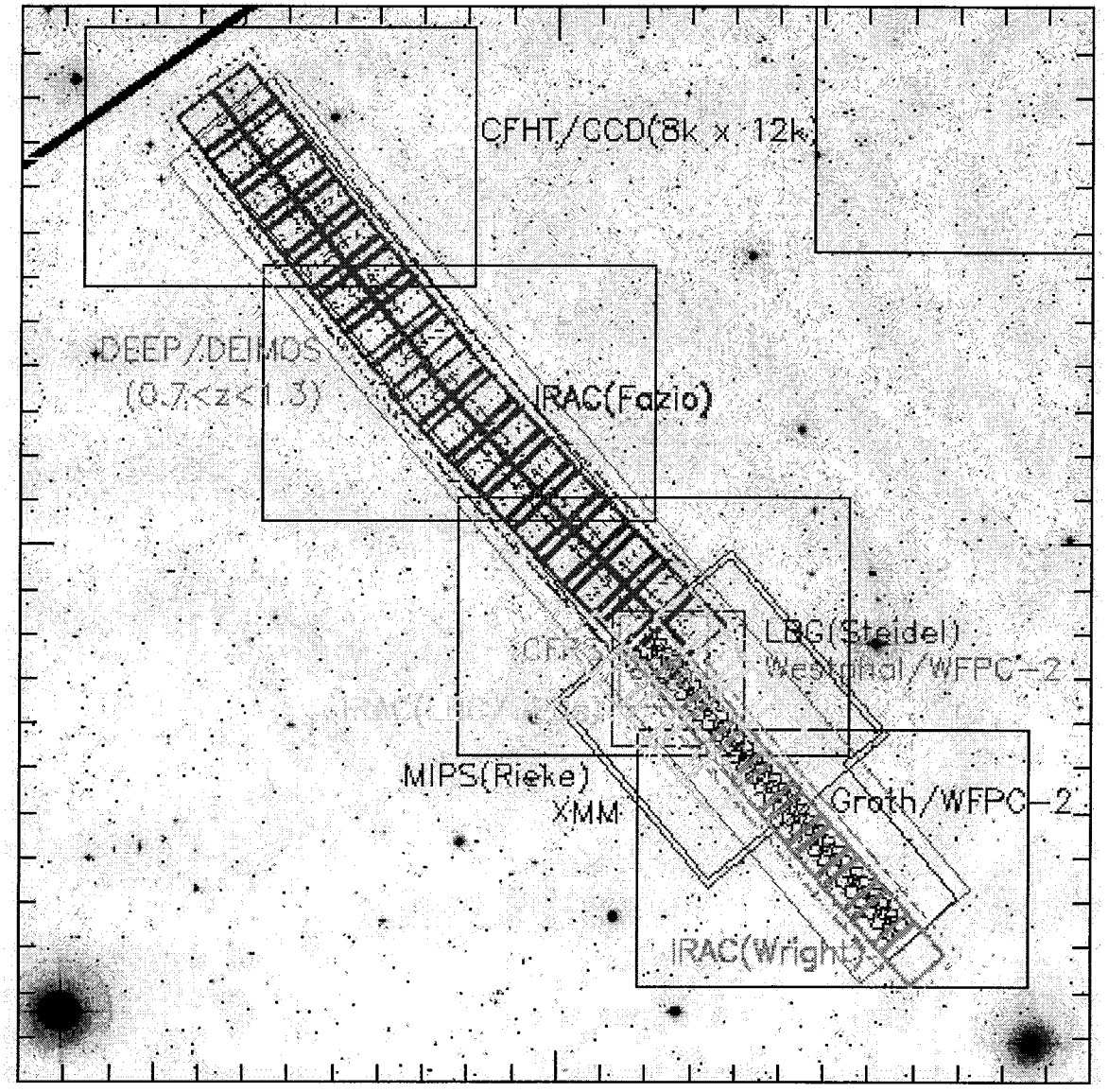
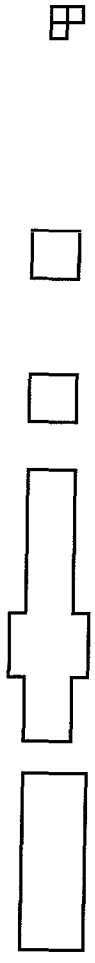


Fig. 2a



- Groth Strip is 28 overlapping WFPC-2 fields: 2800s V, 4400 s I
- High ecliptic & galactic latitude, low IR cirrus: low SIRTF bkgd
- Oriented along ecliptic longitude line - SIRTF scan direction
- Ned Wright designated deep IRAC imaging of Groth Strip as 1st year GTO program, covering nine 5' x 5' fields at 4hr/position
- IRAC Deep Survey will cover 2 x 15 fields to same depth, extending strip 1.25 deg to NE. IRAC will cover 27 x 27' XMM field at ~500 sec/position
- MIPS Deep Survey will cover combined area
- UC DEEP/DEIMOS Keck project will obtain spectra for over 10,000 galaxies in this region

F.5. 26

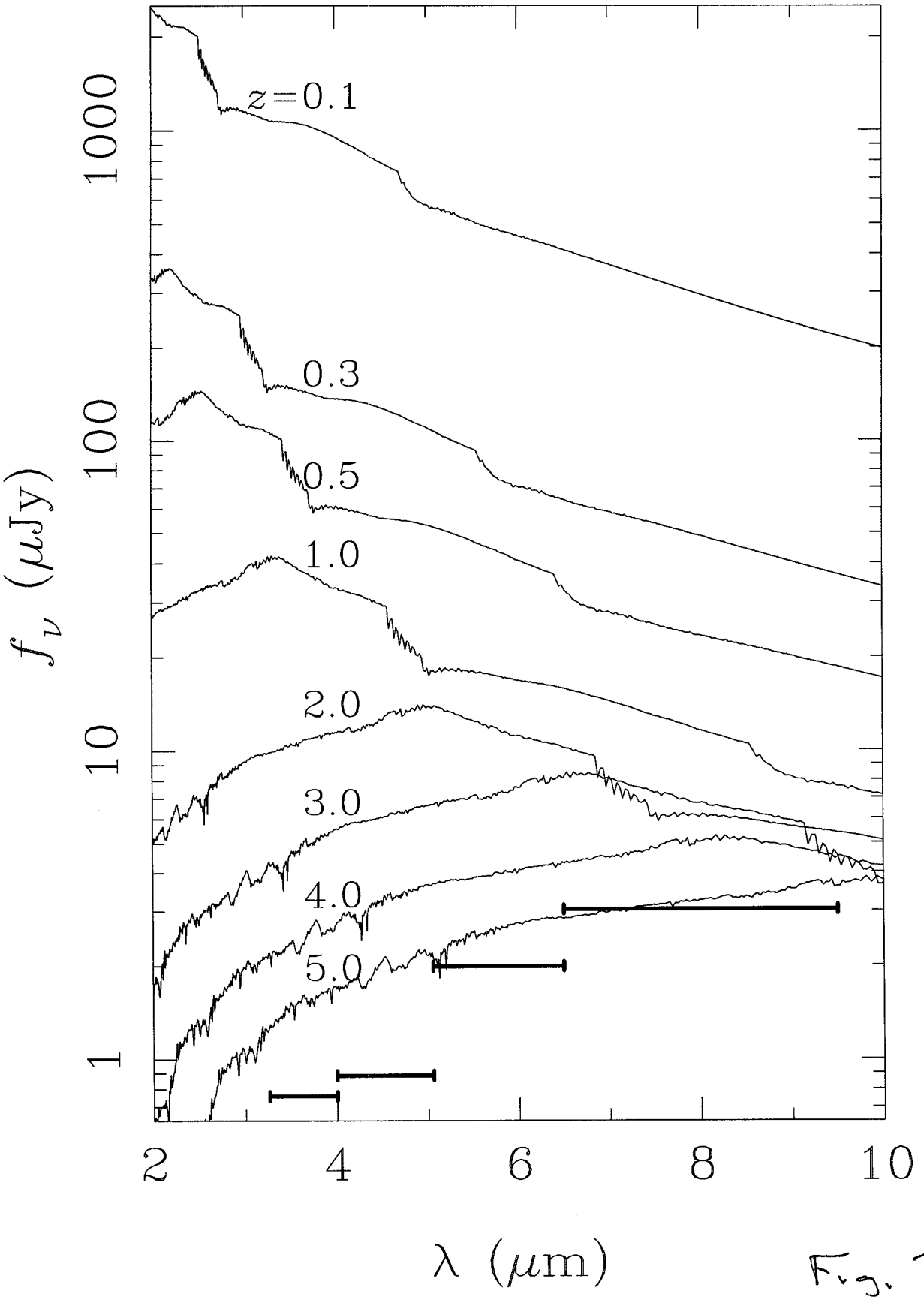
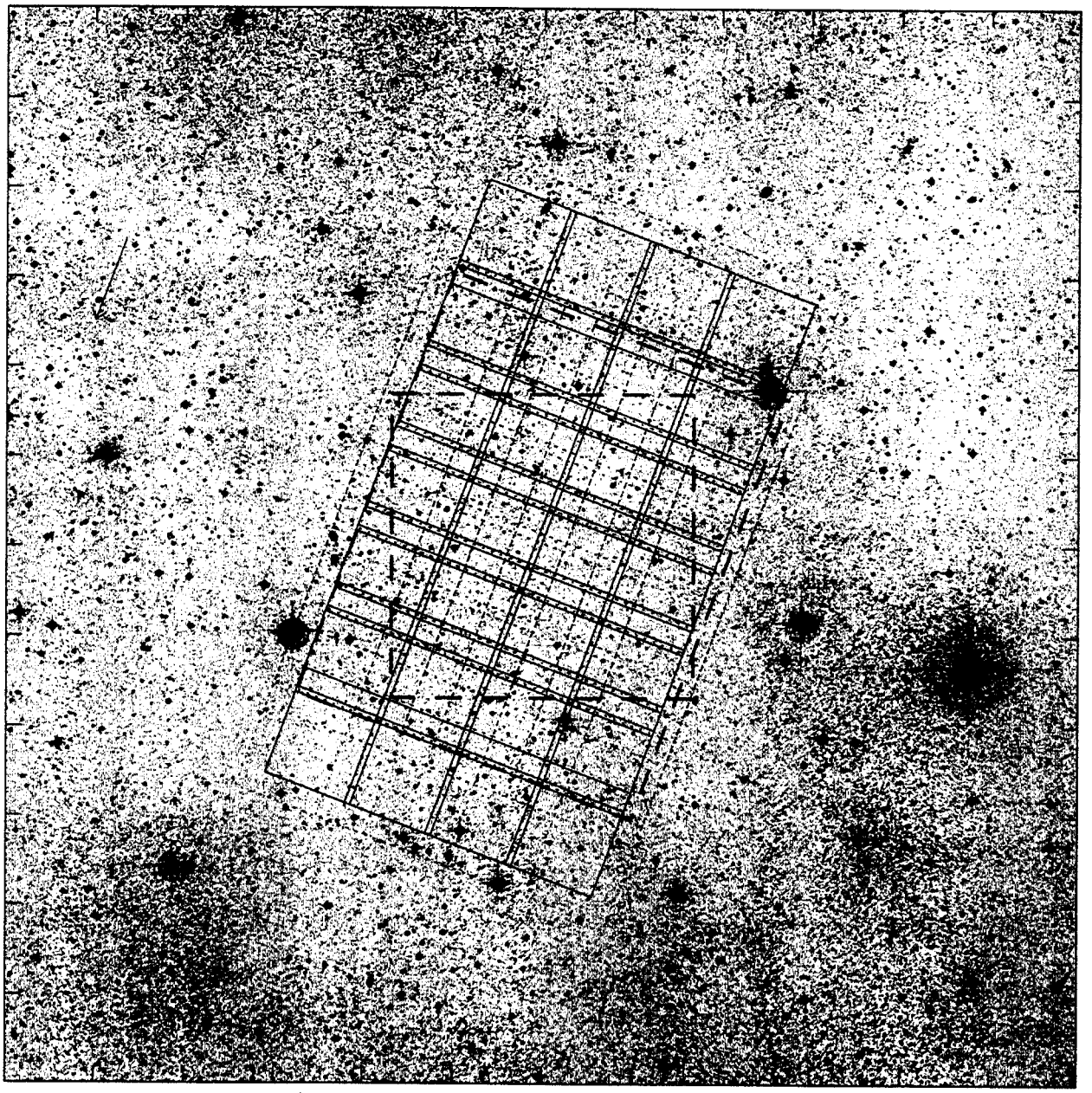


Fig. 3

Fig. 4a

AXAF–South (16.9 x 16.9 sq. arcmin); IRAC/MIPS 20 x 25; (l,b)=(223.6,–54.4)
03:32:28.0 –27:48:30 (J2000); DSS2 image: 1x1 deg; Ecl. (38.1,–45.4)

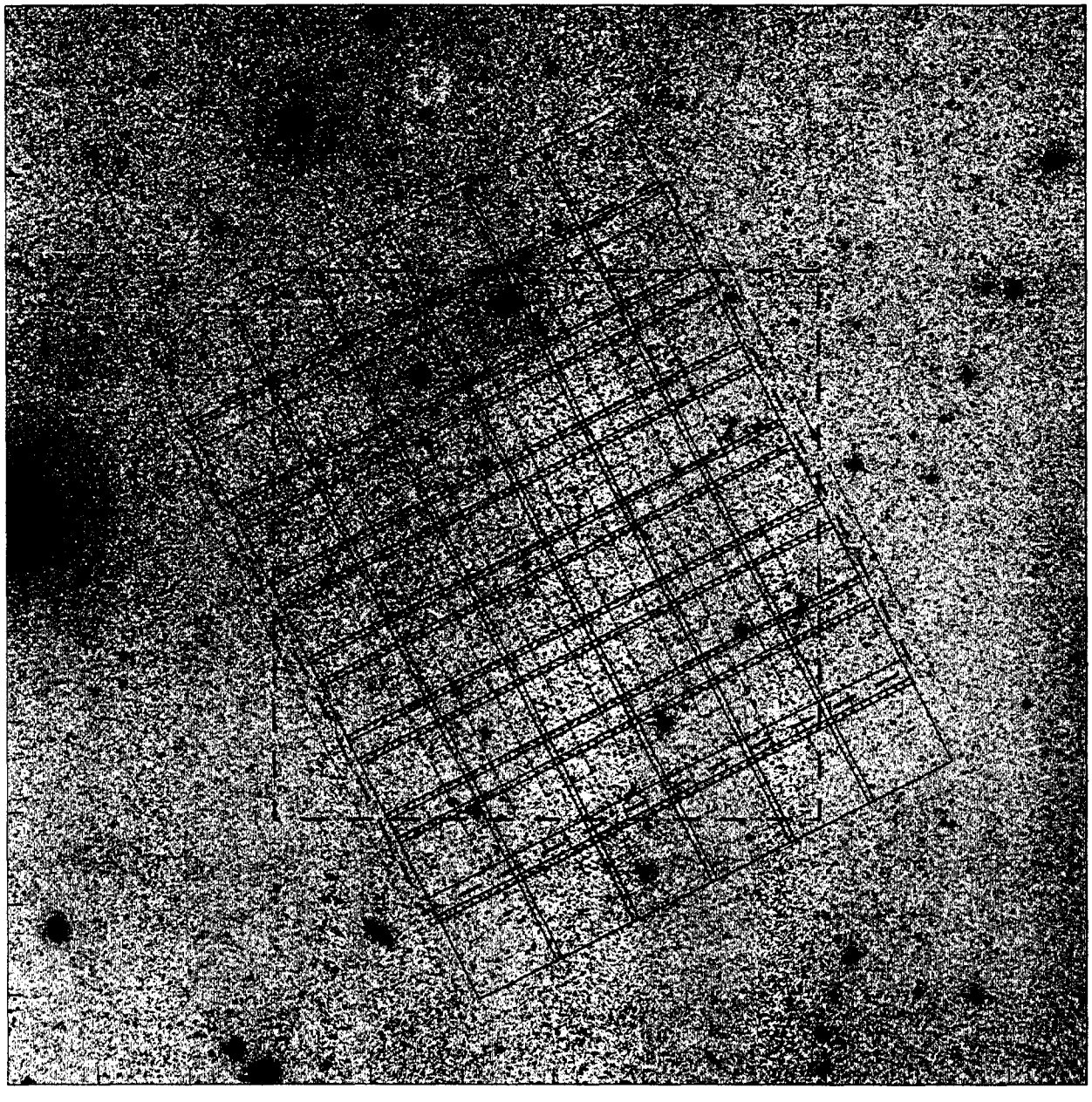


DECLINATION OFFSET

RIGHT ASCENSION OFFSET

Fig. 46

Lockman−Hole (30 x 30 sq. arcmin); IRAC/MIPS 30 x 30; (l,b)=(149.3,+53.1)
10:52:43.0 +57:28:48 (J2000); DSS2 image: 1x1 deg; Ecl. (134.9,+41.2)

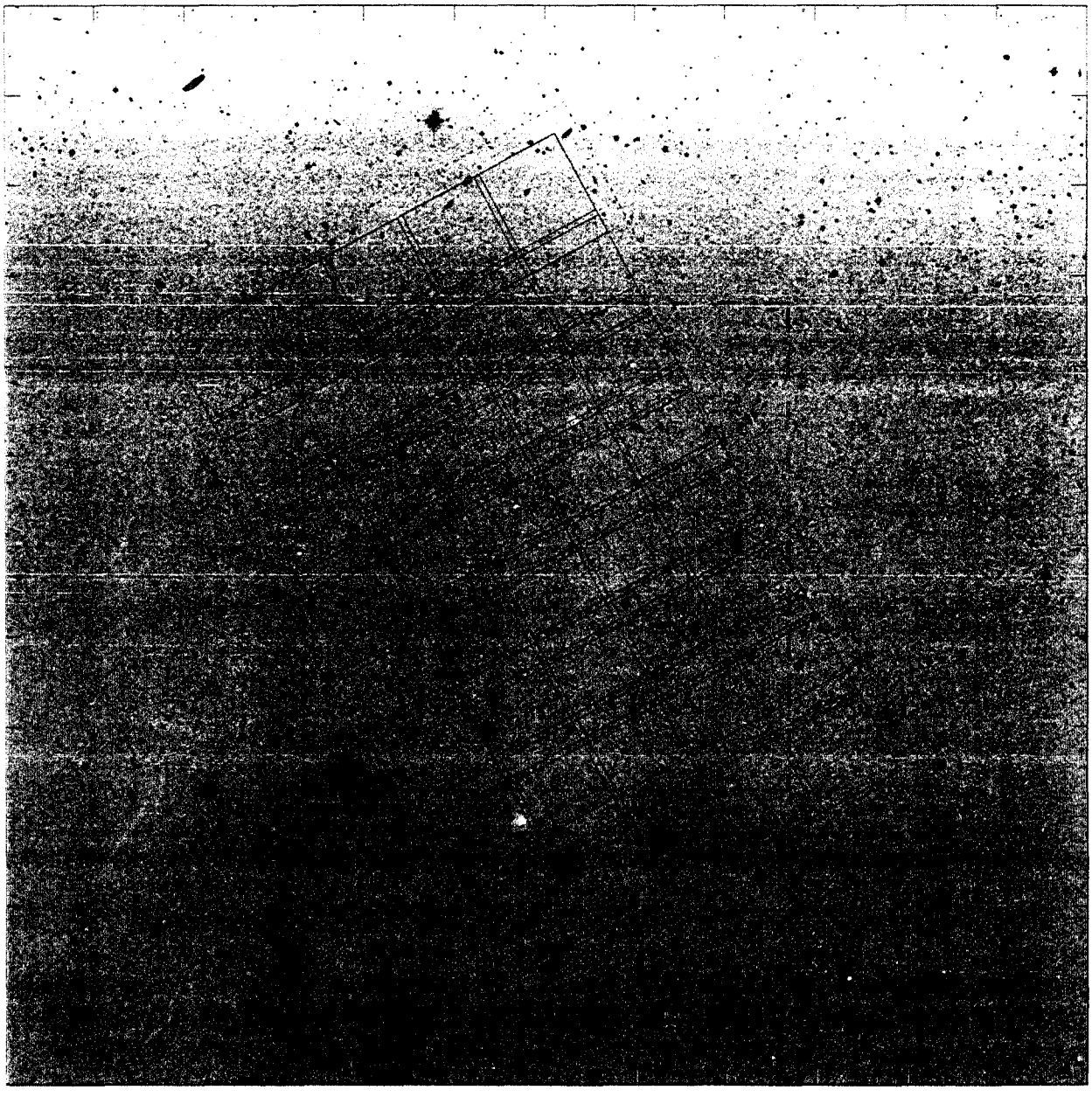


DECLINATION OFFSET

RIGHT ASCENSION OFFSET

Fig. 4c

XMM-Deep (27 x 27 sq. arcmin); IRAC/MIPS 27 x 27; (l,b)=(85.6,-75.9)
13:34:37 -37:54:44 (J2000); DSS1 Image: 1x1 deg; Ecl. (178.5,-37.4)

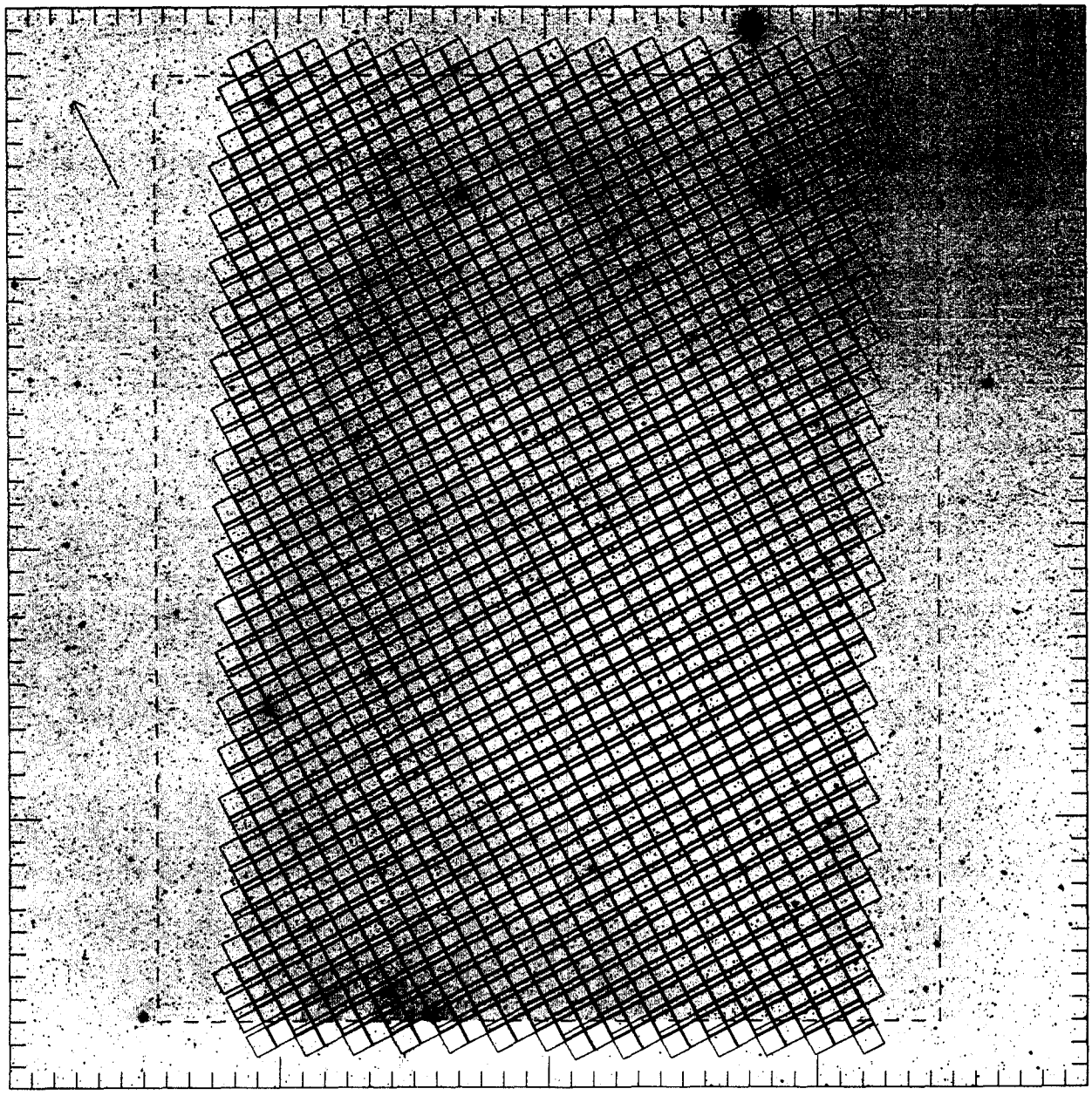


DECLINATION OFFSET

RIGHT ASCENSION OFFSET

Fig. 5

NOAO Deep Field North (2.9 x 3.5 deg); IRAC 8 sq deg
14:30:00 +34:30:00 (1950); Full image: 4x4 deg



RIGHT ASCENSION OFFSET

DECLINATION OFFSET

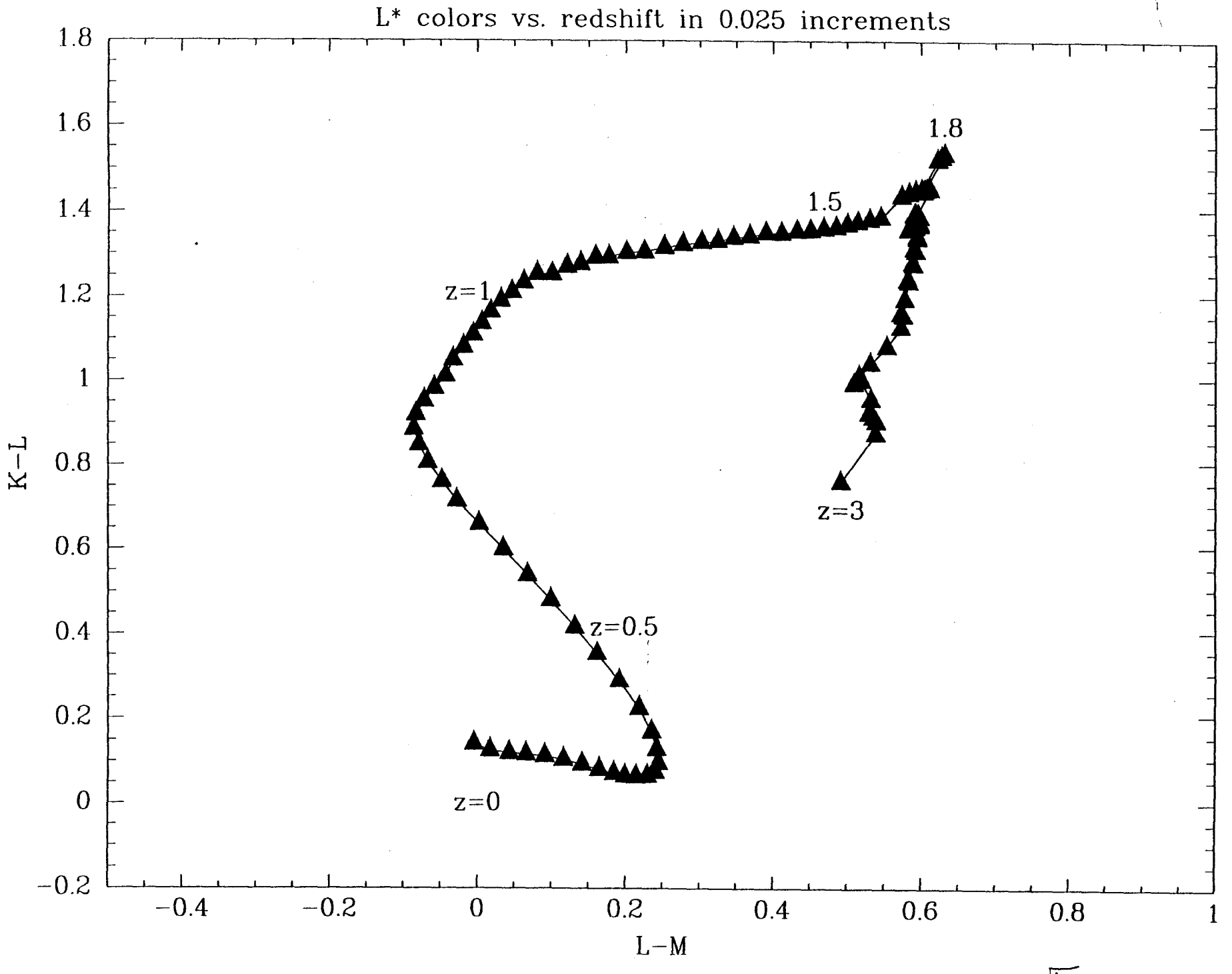

L* colors vs. redshift in 0.025 increments
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
K-L
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
L-M
1.8
1.5
z=1
z=3
z=0.5
z=0

Fig. 6